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REPORTS
STEVENS,
P.R.

Guidelines for assessing the

Signifiance of Rocreational Impacts

In Wilderness Ecosystems: The Integrative Model.

CO-OPERATIVE AGREEMENT

BETWEEN

GRIFFITH UNIVERSITY

AND

THE FOREST SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION,

OGDEN, UTAH

REPORT ON WORK IN

MISSOULA, MONTANA

12 MAY - 12 JULY 1980

GUIDELINES FOR ASSESSING THE SIGNIFICANCE OF RECREATIONAL IMPACTS IN WILDERNESS ECOSYSTEMS: AN INTEGRATIVE MODEL

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September 1980

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1.0 INTRODUCTION

1.1 The Co-operative Agreement

Following extensive discussions between myself and Dr G H Stankey, of the Forestry Sciences Laboratory, U.S. Forest Service, Missoula, Montana, a Co-operative Agreement was signed by the Director of the Intermountain Forest and Range Station, Ogden, Utah and Griffith University. The Agreement is attached to this report. The major objective of the proposed work was to :

> "Develop guidelines and criteria for assessing the significance of soil alterations resulting from recreation use, based upon a review of the literature and field data on soil impacts from recreation use".

I arrived in Missoula on Monday 12 May 1980. Apart from a short trip to eastern Montana to study land use planning for coal strip-mining, I worked at the Forestry Sciences Laboratory on the University of Montana campus until Friday 27 June. Between Sunday 29 June and Saturday 12 July I participated in a research field trip under the aegis of the International Union of Forest Research Organisations Recreation Research Group, which travelled through forests in Colorado, Wyoming, Montana and Washington. I left the USA on Saturday 12 July.

1.2 Purpose of this Report

This report is based on reading, discussions and several short field trips during a total of about 30 days in May and June 1980. It is intended solely for use by members of Research Working Unit INT-1903 at the Forestry Sciences Laboratory, Missoula. Many of the ideas it contains embody concepts

discussed with members of the group, and I cannot claim originality for all of them. This report might contain material suitable for re-drafting as a formal joint publication at a later data. I hope it might stimulate discussion and indicate some promising avenues of future soil-related research.

1.3 Acknowledgements

It is a pleasure to acknowledge the many people and organisations who helped me to make such an interesting journey, which was so professionally and personally rewarding. Foremost amongst the organisations must be the U.S. Forest Service and Griffith University. My colleagues in the School of Australian Environmental Studies made various adjustments to teaching schedules to enable me to leave Griffith University towards the end of the first semester. My warmest appreciation must be for Dr Bob Lucas and Dr George Stankey, for arranging my visit and for providing funds to cover travel and some daily expenses. In the professional context, I have greatly benefitted from the stimulating company and practical help provided by Dr David Cole, whose comprehensive understanding of recreational impacts in wilderness ecosystems was an inspiration to me.

Peter K. Dawkins

(23 : ix : 80)

COOPERATIVE AGREEMENT
BETWEEN
GRIFFITH UNIVERSITY
BRISBANE, AUSTRALIA
AND THE
FOREST SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE
INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
OGDEN, UTAH

THIS AGREEMENT, made and entered into by and between GRIFFITH UNIVERSITY, hereinafter referred to as the "Cooperator," and the Forest Service, United States Department of Agriculture, through the Director of the Intermountain Forest and Range Experiment Station, hereinafter referred to as the "Forest Service" witnesseth:

WHEREAS, the parties hereto are mutually interested and desire to cooperate in conducting certain forestry research work more particularly and fully described as:

Increasing levels of backcountry use are leading to more severe impacts on vegetation and soil. While many investigations have documented the soil impact associated with recreation use, little has been done in establishing guidelines and criteria for evaluating the significance of these impacts. The lack of such guidelines and criteria make impact management difficult.

The Major Objective is:

Develop guidelines and criteria for assessing the significance of soil alterations resulting from recreation use, based upon a review of the literature and field data on soil impacts from recreation use.

AND WHEREAS, pursuant to statutory authority under the Act of June 30, 1978, 92 Stat. 353, Public Law 95-307, the Forest Service is authorized to cooperate with others in accomplishing such research work.

NOW THEREFORE, the parties hereto agree as follows:

A. That the Forest Service shall:

1. Collaborate with the University in the preparation of a mutually acceptable report addressing the objective above,

2. Provide technical advice and consultation in the conduct of research,

3. Make available its equipment and materials, as required, to facilitate completion of the report,

4. Reimburse the University for its direct costs for the items applicable to the work under this Agreement, but not to exceed $3500. Ten percent of this Agreement cost will be retained until a satisfactory Final Report has been accepted by the Forest Service. This is in addition to any Forest Service contribution in the form of services and supplies.

B. That the Cooperator shall:

1. Collaborate with the Forest Service in development of a report assessing the implications of the literature on recreational impact on soils for future research,

2. Provide funds to cover Dr. Peter Stevens' salary.

C. It is Mutually Agreed:

1. That this Agreement may be terminated by either party by giving 15 days' advance notice to the other party in writing, but in no event shall this Agreement extend beyond September 30, 1982.

2. That no Member of, or Delegate to, Congress, or Resident Commissioner, shall be admitted to any share or part of this Agreement or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this Agreement if made with a corporation for his general benefit.

3. That nothing in this Agreement shall be construed as obligating the Forest Service to expend, or as involving the United States in any contract or other obligations for further payment of money in excess of appropriations authorized by law, and administratively made available for this work.

IN WITNESS WHEREOF, the parties hereto have executed this Cooperative Agreement as of the date last recorded below.

Date — For Cooperator

2/28/80
Date

Director, Intermountain Forest and Range Experiment Station

2.0 MODELS OF RECREATIONAL IMPACTS IN WILDERNESS ECOSYSTEMS

2.1 Introduction

Since the development of cybernetics and general systems theory, the construction of many different sorts of models has often proved to be a useful method of conceptualising complex and multi-dimensional natural and man-affected systems. With the use of digital computers, many aspects of systems can be mathematically simulated to provide quantitative estimates of system outputs given certain inputs and rules of system behaviour. Discussions of model building and simulation can be found in Beishon and Peters (1976), States et al. (1978) and many other publications.

Many authors have started to apply modelling techniques to recreation research, or at least to particular topics within this general field. Some recent examples of conceptual models, wherein numerous factors are shown to inter-relate and influence system variables ("Spider-web models") are by Stankey (1972), Liddle (1975), de Benedetti and Parsons (1977) and Wall and Wright (1977). Three different mathematical models related to recreation research might be cited. Wright (1977) simulated potential visitation to new National Parks in Alaska using an extremely complex model incorporating 106 variables and 56 multipliers. van Wagtendonk (1977) investigated the relationships between trail width, pedestrian traffic and maintenance costs with another mathematical model. Lastly, Shechter and Lucas (1980, and others) devised the Wilderness Use Simulation Model, which manipulates wilderness trail routes and their users to optimise management alternatives for wilderness travel. Many other examples could be quoted.

All models, even the most complex, can only be an abstraction from reality. If this were not so, they would approach reality and would therefore not be models. They all suffer from the problems of selecting and simplifying from

reality, and all models can be criticised on their choices of state, driving, rate and auxiliary variables. They are thus subject to continual refinement. The models presented below are no exception to this rule. A second problem with all models is that the system boundaries in both time and space must be stipulated, which again leads to difficult problems of arbitrary inclusion and exclusion. Models using the Forrester system of nomenclature (see below) can force the modeller to use a "linear" rather than "clustered" approach, so that particular state variables have to be separated by a limited number of rate variables, each conditioned by a few driving or auxiliary variables. Even with feedback loops incorporated, this can impose an undesirable degree of simplification on the model, especially where many different physical, ecological and social factors are thought to influence reality.

2.2 Recreational Impacts

Any list of possible primary and secondary recreational impacts becomes extremely complicated, and despite all efforts, can never be comprehensive. A list by Mercer (1980), reproduced here as Table 1, shows this admirably. Clearly, for any sensible approach to the topic such a list must be simplified and impacts classified in various ways. The problem is, of course, that minor impacts in one recreational situation might be major impacts in some other situation, and the choice must always be site-specific and contentious.

In any given situation it should be possible to list and classify the major impacts into various classes of -

direct (intrinsic) and indirect (extrinsic)
trivial and serious
innocent and malicious
transitory and non-transitory
avoidable and non-avoidable

4A

Table 1. From Mercer, 1980

Table 6.3 Impact of recreation on the Victorian countryside

Activity or operation	Area or land type affected	Nature of effects arising	Incidence (time, space, degree)	Some parties interested	Example of problem areas
Aquatic Sports					
1 Swimming, bathing, & surfing	Sea coasts, rivers, canals and other inland waters	Disturbance, litter, erosion of banks, sand dunes, etc., trespass on adjacent private land, const. of car parks, levels, kiosks, etc. in popular areas; massive impact at surf carnivals etc	Mainly summer, week ends, massive, localised	SRWSC, Port Phillip Auth.; National Parks Serv.; Town & Country Planning Bds., Local Gov. Auth. (part. Bayside); Soil Cons. Auth.; Surfing Clubs; Tourist Dev. Auth.	Port Phillip Bay beaches, Gippsland Lakes, Lorne, Torquay, Lake Eildon, Emerald Lake, Phillip Island, Wilson's Prom.
2 Diving & sub-aqua	(as above)	Aids students of lake and marine biology and off-shore geology; disturbance, destruction of aquatic life; cars on beaches (heavy gear)	Mainly summer, week ends, small numbers, very local	Diving & sub-aqua clubs, Port Phillip Auth., National Parks Serv., Local Gov. Auth., Fisheries & Wildlife Dept.	Port Phillip & Western Port Bays
3 Spear-gun fishing	(as above)	Introduces to underwater habitats new conservation problems similar to those created by killing wildlife on land, driving away of fish from inshore waters	(as above)	Fisheries & Wildlife Dept.; Anglers, Port Phillip Auth.	(as above)
4 Canoeing & rowing	Rivers, canals, other inland waters and sea coast.	Disturbance by landing on islands and by penetration into small waterways	Mainly spring to autumn, week ends; limited following, fairly widespread.	Canoeing clubs, anglers, SRWSC, Forests Comm., National Parks Serv., Local Gov. Auth.	Yarra River, Gippsland Lakes, Port Phillip Bay, Gippsland Rivers (e.g. Thompson, Tambo, & Snowy Rivers)
5 Sailing	Rivers, canals, other inland waters and sea coast, and estuaries & reservoirs	Erosion and destruction of aquatic vegetation, dist. of birds, dredging of shallows, cluttering of coastal landscapes by unsightly shore facilities, note for car parks, launching ramps, etc	Mainly summer, some in winter, increasing widespread	Anglers, naturalists, yachting clubs, SRWSC; Port Phillip Auth., Fisheries & Wildlife Dept., Local Gov. Auth., SEC, MMBW, Soil Cons. Auth., National Parks Serv.	Marinas around Port Phillip Bay, Phillip Island, Gippsland Lakes, Lake Eildon, Lake Eppalock, Glenmaggie Reservoir, Mallacoota Inlet, Corner Inlet, Anderson's Inlet, Lake Hume, River Murray
6 Motor boating & cruising	Rivers and canals, other inland waters and seacoast	Noise and mechanical disturbance especially to nesting birds, erosion and destruction of aquatic vegetation, pollution by oil, petrol and sewage, some times conflicts with sailing, canoeing and angling interests.	Mainly summer, small numbers, locational increasing	Motor boating clubs, yacht clubs, SRWSC, Anglers, Naturalists, National Parks Serv., Fisheries & Wildlife Dept.	Port Phillip & Western Port Bays, Lake Eildon, Gippsland Lakes, Lake Eppalock, Two Lakes, Glenmaggie, Corner Inlet, Murray, Lake Hume, River Yarra
7 Speed boating & racing & water skiing	(as above)	Disturbance, erosion, noise, penetration to shallow waters not otherwise affected by deeper draught boats, cars on foreshore, boat launching facilities	Mainly summer, widespread on sheltered waterbodies, rapidly increasing in popularity	Motor boating clubs, Port Phillip Auth., SRWSC, Local Gov. Auth., swimmers, yachtsmen, Fisheries & Wildlife Dept.	(as above)
8 Angling	(as above)	Angling interests have preserved unspoilt many stretches of river and other aquatic habitats and have often successfully combatted water pollution. Most factors are: litter, damage to vegetation, trampling of banks, pollution when motor boats used, disturbance of birds, disturbance of fish	Week ends all year round, but mainly summer, increasing, intense mass in widespread, certain exclusive sites	SRWSC, Angling clubs, Fisheries & Wildlife Dept., Port Phillip Auth.	(as above)
Land Sports					
9 Games on playing fields, commons & parks	Specialised playing fields, parks and open land in and near towns	Destruction of original natural vegetation, but may preserve rural and wildlife features against urban activities	More in winter than summer, especially in school and university term time, intensive widespread, many exclusive sites	Local Gov. Auth., sporting clubs, Soil Cons. Auth.	Numerous throughout Victoria, especially in Melbourne
10 Model aircraft flying	Open land near towns, parks and playing fields within towns	Disturbance to wildlife and amenities, interference with other users	All year round, local small numbers	Model aircraft clubs, local residents, Local Gov. Auth.; Dept. Crown Lands	Dandenong, Police Paddocks, numerous city parks and playing fields
11 Golf	Grasslands especially sandy areas	Some destroying levelling and mowing of vegetation, but golf courses may be beneficial as buffer zones, unlike trampling and reducing dune erosion, golf course roughs beneficial as reservoirs of dune land heath, etc. May take over areas that could be developed as public open space	Local, all zones as located, mainly on exclusive sites	Golf clubs, Local Gov. Auth., Conservation Groups, Soil Cons. Auth.	Numerous throughout Victoria, especially in Melbourne

Table 1. (cont.)

12 Shooting --Game	Rural areas	Destruction of predators; poaching and trespassing; danger to other users of area	Generally all year; widespread; limited following	Farmers; gunclubs; Fisheries & Wildlife Dept.; Dept. of Crown Lands; Forests Commission	Wild deer in central highlands, Grampians, South Gippsland; illegal shooting in Wilson's Prom. Widespread often illegal shooting throughout State of kangaroos, wallabies, rabbits, koalas, etc
13 Shooting --wildfowl	Foreshores; estuaries and inland swamps and lakes	Properly conducted with restraint can increase local care for wildfowl habitats and discourage excessive concentrations. Often indiscriminate shooting of protected species and disturbance to wildfowl roosting areas. Artificial stock may create local problems	Feb.-April; localised moderate following fairly widespread.	Local wildfowlers clubs; SRWSC; Local Gov. Auth.; National Parks Serv.; Fisheries & Wildlife Dept	Gippsland Lakes; Lake Elliden; Western District; Lakes (e.g. Corangamite); Lake Boga; Lake Eppalock
14 Horse racing	Open grassland, heathers and downs.	Exercise and practice areas may provide and preserve valuable wildlife habitat; some race meetings occasional heavy traffic damage and litter on open courses	Intense, massive local effect during meetings, but of short duration (only a few days each year)	Race course owners; residents near race courses; jockey clubs; Dept. Crown Lands; Soil Cons. Auth.	Flemington, Sandown, Country Race Courses
15 Riding & pony trekking	Rural areas, some coastal areas and hill country.	Erosion of sand dunes and slopes, trampling especially of verges, woodland ridges and ground flora. Damage to experimental areas	All year round; widespread, limited following.	Riding schools; Dept. Crown Lands; Local Gov. Auth.; Farmers; Local Residents; Soil Cons. Auth.	Outer suburbs of Melbourne, especially lower slopes of Dandenongs, e.g. Hillam, Pakenham, Croydon, etc.; numerous rural areas throughout State
16 Motor rallies & cycle scrambles.	Rough, often hilly land in outer suburbs and rural areas	Noise, disturbance, erosion (severe in scrambling), damage to vegetation, gates left open, spectators add to vegetation damage, illegal use of footpaths	All year round; local; limited though increasing following	Motoring and motor cycle clubs; farmers and rural dwellers; Crown Lands Dept.; Forests Comm.; local conservation societies; Soil Cons. Auth.	Outer suburbs of Melbourne, especially lower slopes of Dandenong and in Broadmeadows, Keilor area
17 Private flying	Grasslands or other suitable open areas	Disturbance, low flying noises	Small low flying planes often operating continuously over relatively restricted circuit, increasing in popularity	Dept. of Civil Aviation; local residents; flying clubs	Outer suburban and rural air fields, e.g. Whittlesea, Tyabb, etc
18 Gliding	Upland areas with suitable escarpments for updraughts	Attraction of crowds of visitors, traffic congestion, litter, trampling, noise of power launching	All year round, local, limited following	Gliding clubs; Local Gov. Auth.; local farmers and residents	Bacchus Marsh.
19 Bush-walking	Especially in upland, forested areas often in national parks or on Forest Commission land	Little effect in rarely visited wilderness areas (e.g. Cobberas of East Gippsland) but often marked effect on popular areas e.g., Wilson's Prom., Lerderderg Gorge. Heavy usage causes trampling and stripping of vegetation, irresponsible conduct involves disturbance to wildlife and game, forest fires, erosion, litter and may give rise to access arguments	All year round, widespread, large numbers in a few favoured areas	Bushwalking clubs; Forests Comm.; National Parks Serv.; S.E.C.; Soil Cons. Auth.; Dept. Crown Lands	Heavy seasonal usage at Wilson's Prom.; Lerderderg Gorge, Tarn Karing, Mt. Baw Baw, Mt. Hotham, Mt. Buller, less extensively used areas e.g. Bogong High Plains, Cobberas, etc.
20 Climbing & Auxiliary Camping	Mountains and cliffs	As with bushwalking often encourages appreciation of wilderness and vigilance over remote unspoilt places. Irresponsible practices may involve disturbance, erosion, removal of vegetation, fires, litter	All year round, especially weekends, local but intense, limited	Bushwalking & climbing clubs; Local conservation groups; Dept. Crown Lands; Forests Comm.; Soil Cons. Auth.	Mount Arapiles
21 Caving	Limestone areas	Responsible action results in subterranean conservation but damage can be caused by unskilled explorers and specimen collectors. Disturbance of fauna, pollution of subterranean waterways. Camping outside cave entrances leads to litter and damage to vegetation	All year round, especially weekends, local, limited	Caving clubs; Dept. Crown Lands; Fisheries & Wildlife Dept.; Local conservation groups	Buchan, Lower Gippsland Region
22 Skiing	Mountains	Disturbance and damage to soil and flora regeneration, bulldozing of banks to encourage snow accumulation may accelerate erosion. Tree cutting, unsightly development of ski tows, ski lodges, etc	Winter, localised but intensive impact increasing at the seasonal rate	Forests Commission; Soil Cons. Auth.; Land Conservation Council; SEC; Dept. Crown Lands; National Parks Serv.; Alpine Resorts Dev. and Advisory Committee; Fed. Vic. Ski Clubs	Mt. Buller, Mt. Hotham, Falls Creek, Mt. Baw Baw, Mt. Buffalo

Table 1. (cont)

23 Picnicking or barbecuing	Attractive rural areas, often wooded, coastal areas and areas adjacent to natural or artificial water bodies	Disturbance, litter, trampling, pollution, fires. Car parking and sanitation problems, radio noise, bushfire danger damage to tracks and verges.	Summer, widespread, massive, especially at weekends and increasing rapidly	Farmers and land owners, local committees of management Dept Crown Lands, Forests Commission, Soil Cons. Auth., MMBW, CHB; National Parks Serv	Shorbrooke Forest, Fern Tree Gully National Park, You Yangs, Mt Macedon, Mornington Peninsula, Tourourong Reservoir
24 Camping & Caravanning	Coast, especially foreshore reserves, rural areas, especially adjacent to natural and artificial water bodies.	Disturbance of wildlife, trampling of vegetation; bushfires; litter; sanitation and car parking problems and provision of numerous services, e.g., electricity, water supply; noise, trespassing on adjacent private land; cluttering of coast if care not taken over siting	All year round, but especially summer, widespread, massive especially at weekends and increasing rapidly	Farmers, Crown Land Dept.; Forests Comm.; National Parks Serv.; Local Committee of Management, SEWSC	Mornington Peninsula foreshore (e.g. Rosebud, Pye, Dromana); Tidal River, Lorne, Torquay, Portarlington, Inverloch, Lakes Entrance, Mallacoota, Fraser National Park, Mildura, Upper Yarra River, Halls Gap
25 Motoring & sight seeing from vehicles or stopping places.	Mountains, national parks, "beauty spots", beaches, rivers, margins of inland reservoirs etc., accessible to motor vehicles	Organised coach tours result in severe trampling around stopping places; litter; pollution at lay-bys; soil eroded by vehicles; traffic congestion and damage to verges; roadside land and approaches to beaches and other attractions cars driven onto dunes and foreshore, bushfire danger	Large scale, massive impact, with peak in summer, locally intense	CPD, National Parks Serv.; Soil Cons. Auth. Forests Comm.; Local Gov. Auth.; Crown Lands Dept.; Port Phillip Auth	Dandenong Hills, Mornington Peninsula; Phillip Island; Wilson's Prom.; Fern Tree Gully; You Yangs; Grampians; Mt. Macedon
26 Fixed accommodation (holiday homes, week enders); hotels, etc	Rural, especially coastal areas and areas adjacent to water bodies	Good siting and design minimize impact of accommodation on landscape, which can otherwise be severe (urban sprawl in a rural setting); sanitation problems; stepping vegetation; land speculation results in alienation from the public domain, often with little chance of areas being built on	Pressures for holiday home sites on the coast are increasing, 'massive' in certain localised areas	Town & Country Planning Board, Port Phillip Auth.; Local Gov. Auth., Real Estate agents, Conservation groups	Phillip Island, Mornington Peninsula, Gippsland Lakes
27 Chairlifts, viewing towers, observation posts, etc	Rural, especially hilly areas and forests	Often unsightly development, vegetation cut and wildlife disturbed, large numbers of visitors attracted to (normally quite isolated areas), trampling, litter	All season, but mainly summer, local	Local Gov. Auth., Chairlift owners, Forests Commission	Dromana, Fern Tree Gully, Grampians, Wilson's Prom.
28 Gem hunting	Areas where the geographical structure is favourable for precious stones, gold, etc., often riverbeds, coast, etc	Trampling, stripping of vegetation, digging and erosion, disturbance of wildlife habitat	All year round, but particularly, as weekends in summer, intense locally	Local Gov. Auth., Dept. Mines, Crown Lands Dept., farmers and private land owners, Forests Comm.; MMBW, Soil Cons. Auth.	Mt. Leo area, Warrandyte and Upper Yarra Rivers, Beechworth, environs of Bendigo and Ballarat
29 Photography and/or watching flora and/or fauna	Mainly water areas of interest to naturalists particularly wildlife reserves and national parks, but also suburban areas, creeks and commercialised areas (e.g. Healesville)	Disturbance, trampling near popular sites, overall flora may result in loss of species, desertion of nest, etc., litter, pollution, noise, etc., at commercialised sites, e.g. Penguin Parade, Phillip Island	Especially in summer and weekends, limited but intense locally	Field Nats. Club, Education & Wildlife Dept., Australian photographic Local Gov. Auth., Commercial interests, Nat. Parks Serv.	Shorbrooke Forest, Wilson's Prom, Wyperfeld, Phillip Island
30 Conservation (nat. parks, floral & faunal reserves, forest reserves, etc.)	Wild and uncultivated areas and open land. Conservation vigilance extends to other types of areas as occasion arises. Defining an area as a conservation area draws public attention to it. Popularity may threaten the values it was designed to protect	Concentration of use by scientific workers, naturalists, geologists, general public, etc., use of sites for experiments and new treatments for management of vegetation and animal populations, attempts to revive or restore damaged habitats	All year round, but particularly during spring and summer	Field Nats. Club's, Soil Cons. Auth., Forests Comm., National Parks Serv., Fisheries / Wildlife Dept	Wilson's Prom, Wyperfeld Nat. Park, Shorbrooke Forest, Healesville Faunal Reserve

(Adapted from *The Countryside in 1970*. Proceedings of a Study Conference held by The Nature Conservancy at a meeting in London, 1963, pp. 112-151)

and perhaps other classes. Most recreation managers probably do this intuitively anyway, and thereby attempt to allocate scarce resources of time, labour and money to solve problems which are perceived to be direct, serious and non-transitory. I am not familiar enough with the U.S. recreation scene to comment on management methods and their efficiency, but there are many examples in Australia where this logical process has obviously not been followed. Frequently, facilities such as barbeques, tracks, carparks and toilets are provided in response to perceived needs on an ad hoc basis, often politically inspired, without clear consideration of their real importance within the whole system of perceived needs and perceived impacts. At least three approaches could ameliorate these problems :

(i) Rigorous use of the Recreation Opportunity Spectrum (Clark and Stankey, 1979) to specify sites according to their role in providing desired recreational opportunities and satisfying recreational experiences, and thereby stratifying the whole spectrum into more clearly perceived and manageable units for management consideration.

(ii) Better knowledge of the magnitude and importance of site response to recreational use, and better understanding of the degree of linkage between use per se and effects of use.

and (iii) More comprehensive and realistic models of the integrated inputs, outputs and feedback loops related to recreational use of particular sites, however defined.

Restricting our attention to recreation in terrestrial wilderness ecosystems, and excluding aquatic ecosystems, esoteric recreations such as mechanical climbing, "front-country",

and effects of motorised and motor-aided recreation, one classification of recreational impacts could be as follows. Impacts, compiled from many different sources, are listed in no particular order.

Some extrinsic impacts of recreation in wilderness ecosystems

(i) Impacts related to travel.

- accidents en route (local medical care, hospitals)
- costs of private transport (fuel, lubricants, maintenance, insurance, depreciation)
- costs of public transport (including infrastructure)
- use of adjacent areas for transit and parking
- road provision and maintenance
- law enforcement
- accommodation en route and adjacent

(ii) Impacts related to preparation.

- sales of durable equipment (personal gear, transportation)
- sales of consumables (food, fuel, packaging)
- hire of equipment
- hire of pack and riding stock (animals, feed, equipment)

(iii) Impacts on adjacent areas.

- disturbance of private landholders (fences, stock, vandalism)
- effects of reservation of recreational area (shelter of feral animals, fire policies, weed control, exclusion of agricultural and logging interests)
- use of adjacent areas for transit and parking

(vi) Impacts related to provision of the recreational opportunity.

- effects of reservation of recreational area
- provision of search and rescue facilities and services

Several of these extrinsic impacts occur under more than one heading. I think it is fair to say that, in Australia, public attention has been almost exclusively focussed on this class of impacts, rather than on those more closely related to site disturbance (intrinsic impacts). Most of the major controversies are concerned with impacts on adjacent areas, and particularly the effects of reserving given recreational areas.

Some intrinsic aspects of recreation in wilderness ecosystems

(i) Transitory impacts.

- noise
- social effects of perceived crowding in transit (encounters, party size, party behaviour)
- social effects of perceived crowding on site (encounters, party size, party behaviour)
- aesthetic effects (sight of visitors and visitor equipment)

(ii) Non-transitory impacts.

- garbage
- attraction or repulsion of wildlife
- change of wildlife behaviour (feeding, breeding, hibernating, resting, extermination)
- non-transitory aesthetic effects (landscape alteration, vandalism, permanent structures)
- ecological effects on plants and soils

- fires in locality
- fires and fire management on an areal basis
- management techniques
- effects of packstock and riding stock

Ecological effects will be considered in greater detail in Section 3.0.

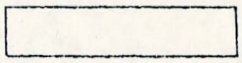
Other classes of impact (trivial/serious, innocent/malicious, avoidable/non-avoidable) may be compiled from the above lists for particular sites, which might clarify the necessity for management and the possible options.

2.3 Nomenclature

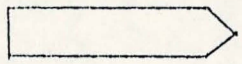
Most conceptual models comprise a series of boxes connected by lines with arrows, indicating flows of matter or energy between objects (such as soil moisture) or states (such as soil temperature). Flows may be positive or negative and feedback loops may or may not be present. Decision-making models (for example, Loendorff, 1977) intersperse decision boxes (branching points) along lines depicting chronological flows of activities. Models using the Forrester nomenclature (see, for example, Forrester 1971) show the changes of state between sources and sinks external to the system by using boxes called state variables (ecosystem components), with each state variable being separated by one or more process valves (rate variables) which control the rate of flow of matter and energy through the system. Both rate and state variables can be influenced by driving variables, connected to them by dashed or dotted lines of information flows. Driving variables may, in turn, be influenced by auxiliary variables which are external to the system and are not part of the feedback loops within it.

For simplicity, the models presented below use the following symbols :

source or sink



state variable



driving variable

material or energy flow

information flow

( ) auxiliary variable

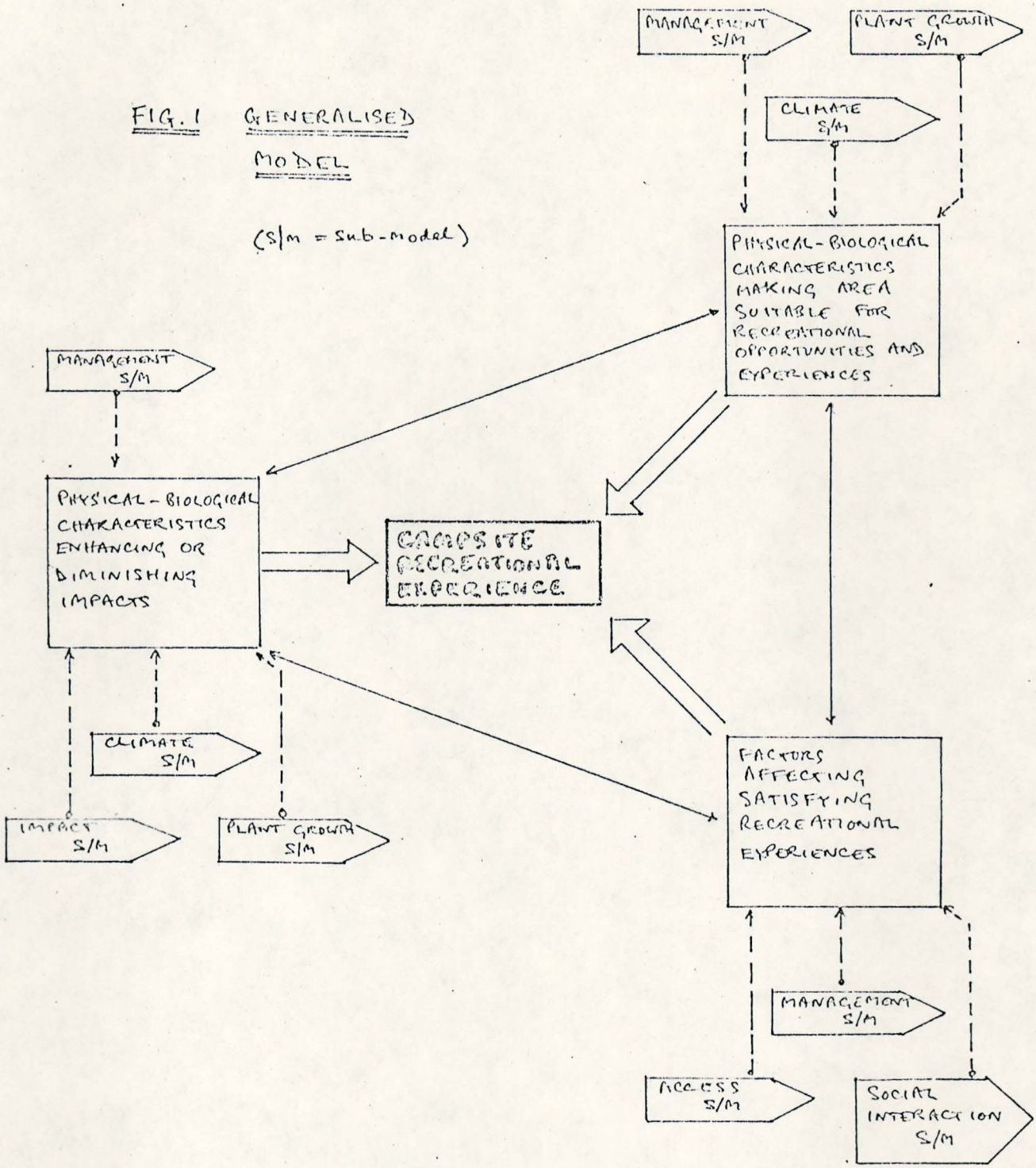
2.4 Models

The models presented in this report (Figs. 1-7) are an attempt to depict those factors influencing the achievement of a satisfying recreational experience in a terrestrial wilderness setting. Specifically, the system boundaries in space are related to campsite experiences, since most wilderness recreationists will spend at least half their time in such situations, and the potential for impact is probably greatest there.

The generalised model (Fig. 1) shows a campsite recreation experience as strongly affected by three major factors, themselves inter-related. Certain physical and biological characteristics make an area (campsite) suitable for recreational opportunities and resultant experiences, and the extent of satisfaction derived from the experiences is affected by these characteristics and by access, management and social interaction. In turn, both the suitability characteristics and the extent of satisfaction affect, and are affected by, those characteristics

FIG. 1 GENERALISED MODEL

(S/m = Sub-model)



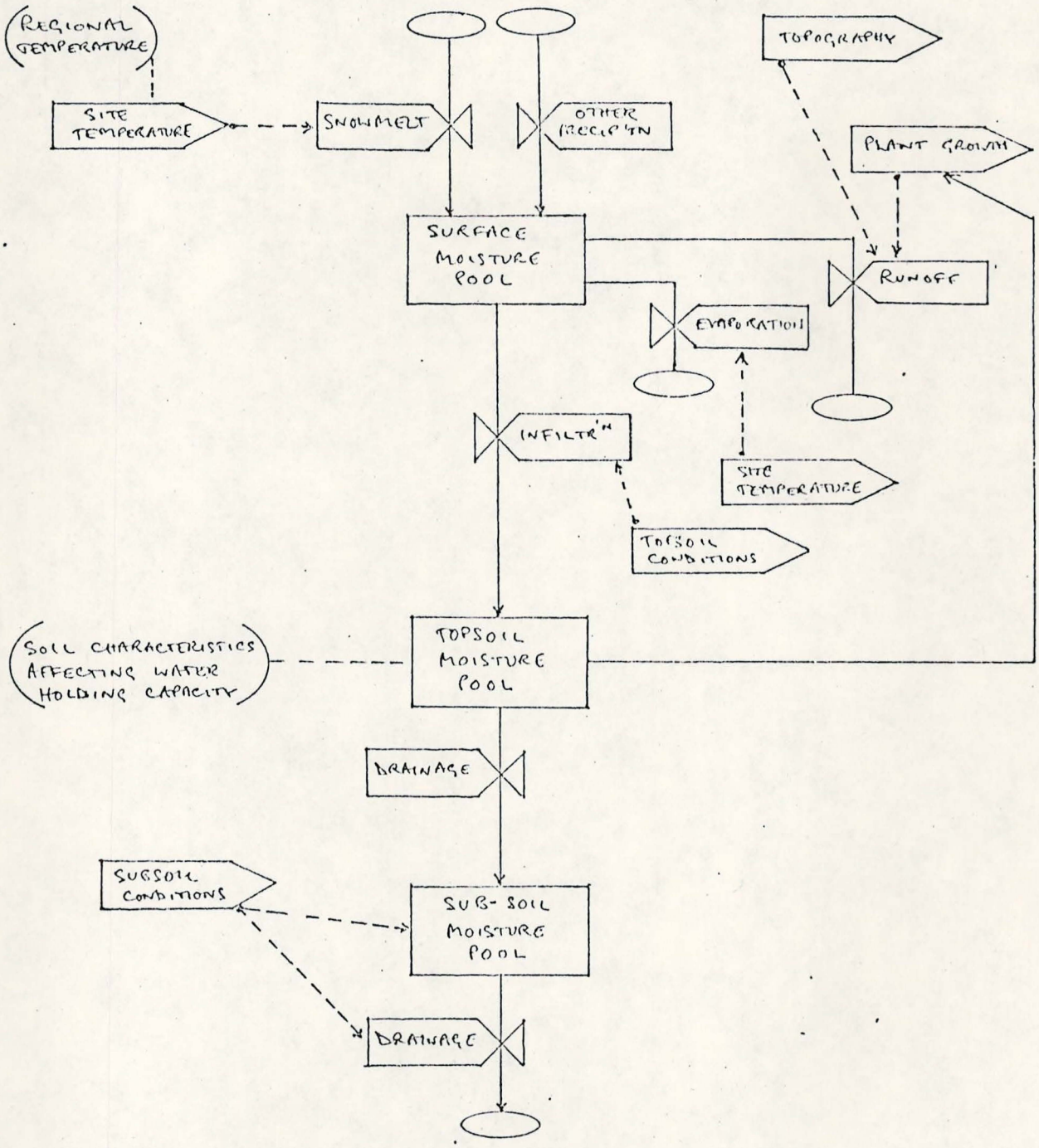
of the site which enhance or diminish impacts. The sub-models attempt to illustrate some of the major influences on the generalised model.

Climate and plant growth sub-models (Figs. 2, 3) are obviously closely inter-related. I have concentrated on topsoil moisture as the central resultant of precipitation and temperature factors in combination with various soil characteristics. Topsoil moisture (amount, and rate of supply to plants) is incorporated in many places in Fig. 3, which in turn affects addition and subtraction of organic detritus and soil organic matter. Several strong feedback loops influence plant growth through plant nutrition. The roles of wildlife, intra-soil flora and fauna, recreational stock and direct non-transitory ecological effects are clearly seen. Many authors (see, for example, Hendee et al. 1978, p. 194) have discussed the importance of the decomposition cycle in forest ecosystems. Some factors affecting seedbed formation and establishment of vegetation (see, for example, de Benedetti and Parsons, 1977, p. 1309) have been included in the sub-model.

Sub-models of access (Fig. 4) and management (Fig. 5) are obviously important influences on social interaction (Fig. 6). I see access as being primarily influenced by topography which, with management regulations, governs the means of conveyance available and adopted. The importance of access as an "opportunity setting factor" has been stressed by Clark and Stankey (1979). Given a particular topographic and regulatory context, the ease of access is affected by five driving variables: in my view time is generally the most important as it strongly influences the markedly uneven distributions of access points and trail use demonstrated by, for example, Stankey et al. (1976). Such maldistributions clearly influence social interactions and recreational impacts.

Management influences (Fig. 5) are seen as affecting the potential for satisfying recreational experiences initially

FIG. 2 CLIMATE SUB-MODEL



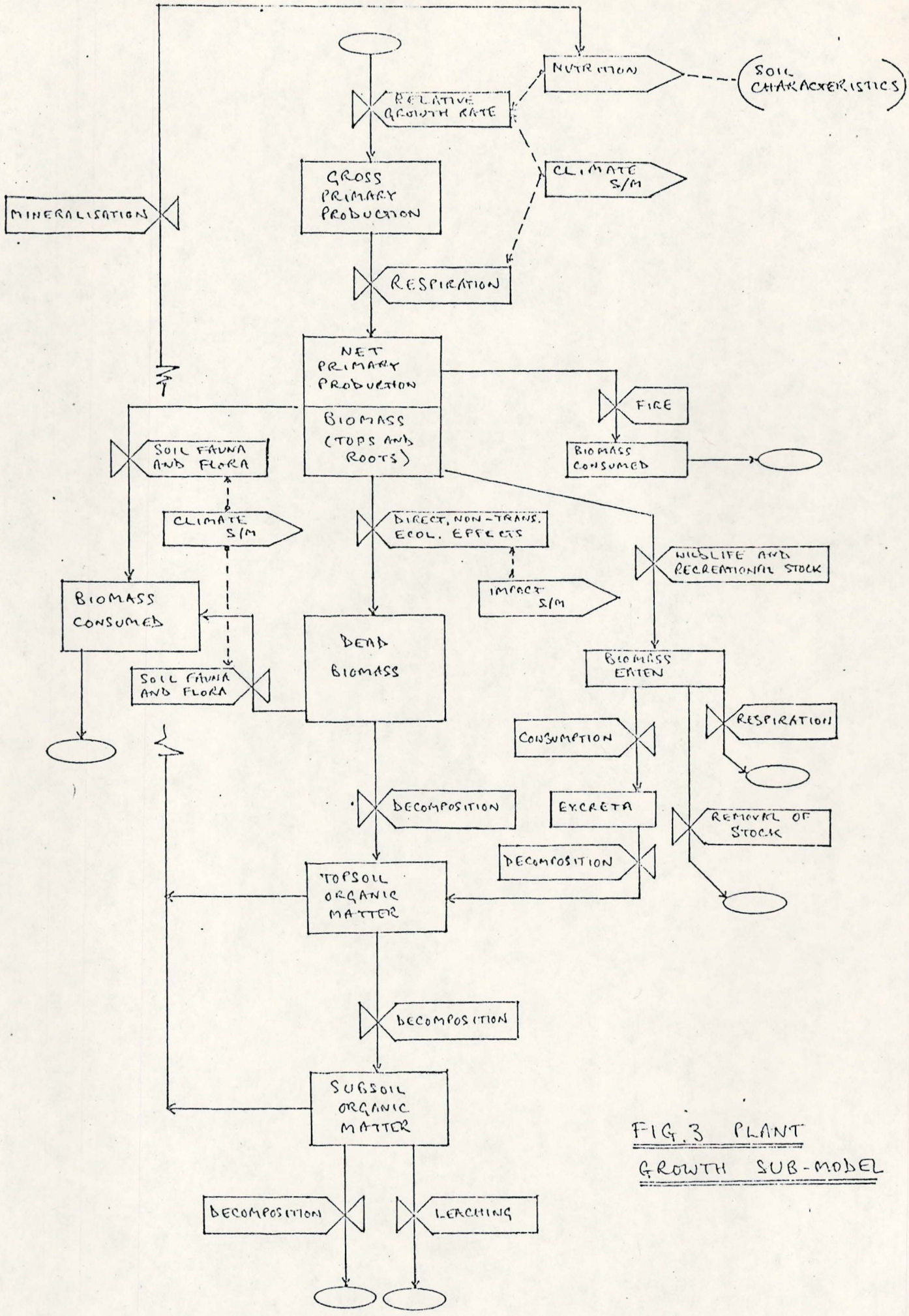


FIG. 3 PLANT GROWTH SUB-MODEL

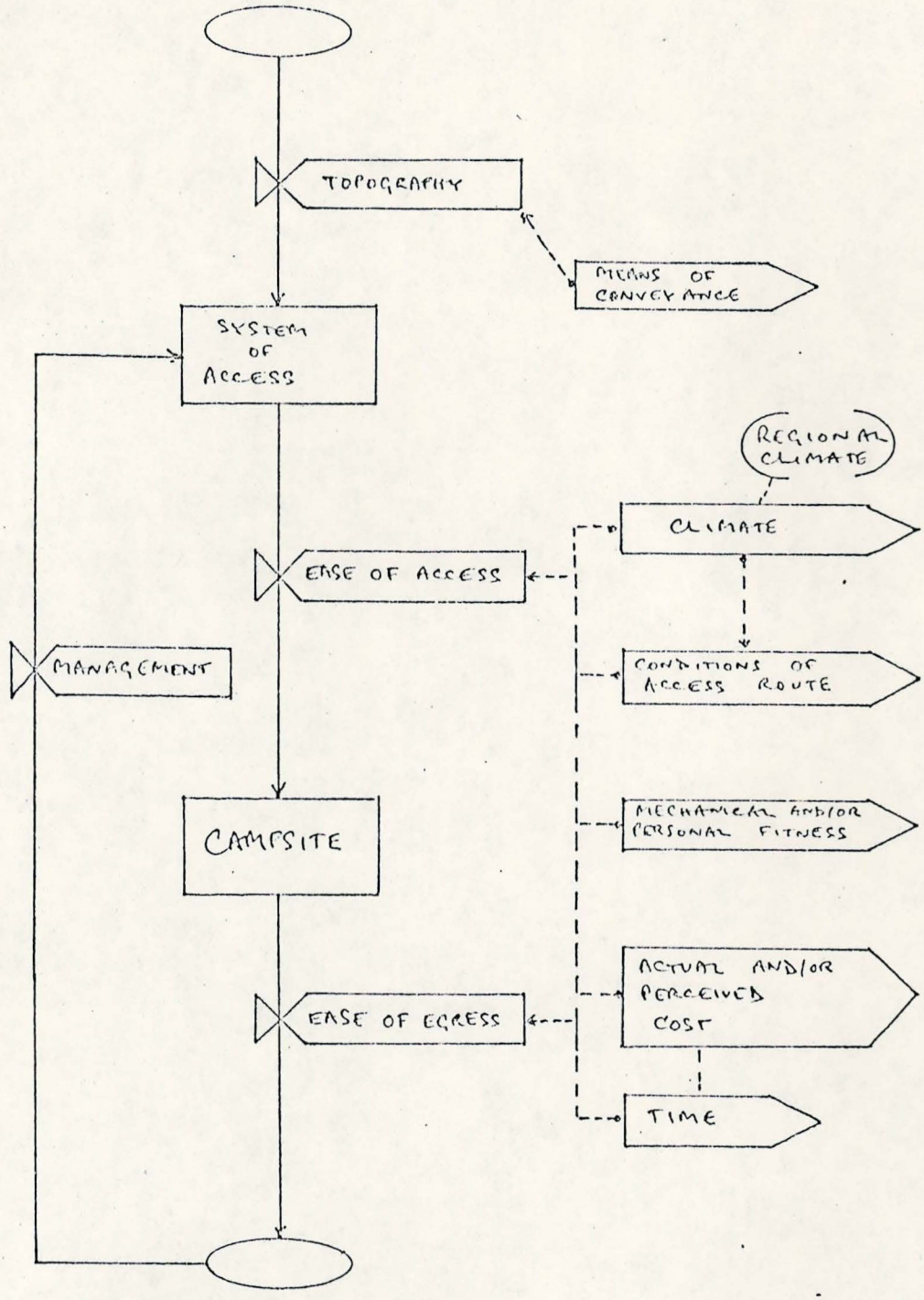


FIG. 4 ACCESS SUB-MODEL

through indirect (largely non-recreational) management of wildlife, grazing, logging and fire. Control of access is important in several parts of the sub-model. Satisfying recreational experiences are thus achieved through the influence of other driving variables. I feel that post-experiential management factors (those applying off-site with respect to the camping and recreation zone) could also be important: these could include control over egress routes, parking, traffic jams, officious treatment on departure and even annoyance or pleasure at being requested to complete recreational survey forms. One feedback loop is shown, to indicate management which changes the systems and ease of access.

The social interaction sub-model (Fig. 6) is an attempt to depict the extraordinarily complex reactions of wilderness recreationists. They move from a general desire for recreation (the source outside the system), through selection of a stratum within the recreation opportunity spectrum and thence to expectations and eventual achievement of satisfying recreational experiences. These should then become the sink, and the source and stimulus for further recreation. The sub-model attempts to incorporate factors discussed by many authors, including Stankey (1972), and despite simplification is still unduly complicated and imprecise. Perhaps this is inevitable with a sub-model of this topic.

I have tried to depict recreational impact (Fig. 7) as a linear model through "potential for suffering from impacts" (site fragility), "transitory site change" and "non-transitory site change". The only feedback loop shown is through management, although there should be other loops, especially between various driving variables. The sub-model draws on the work of many authors, though it does not include all of the factors mentioned by workers such as Liddle (1975), de Benedetti and Parsons (1977) and Wall and Wright (1977). Section 3.0 of

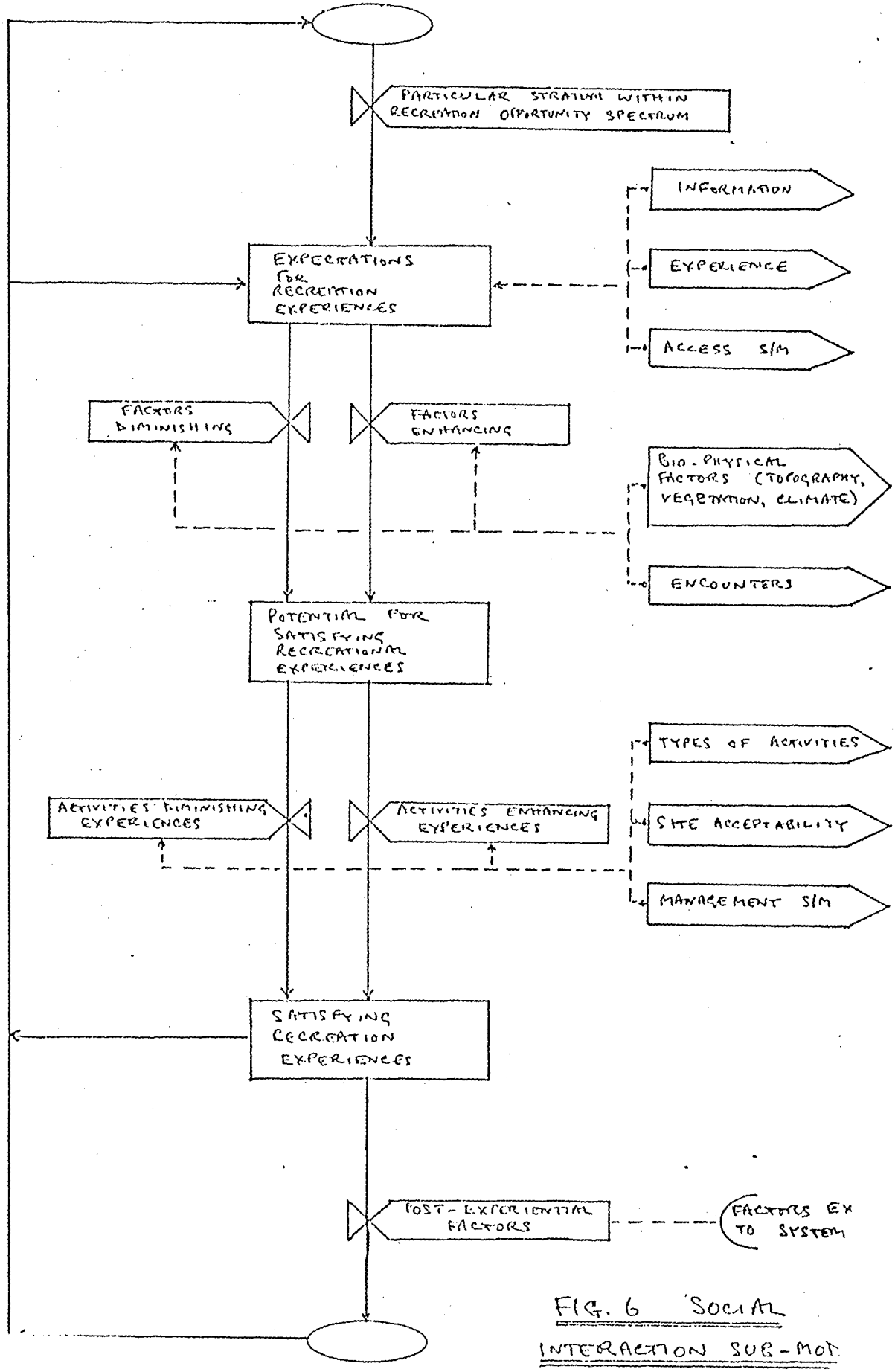


FIG. 6 SOCIAL INTERACTION SUB-MOD

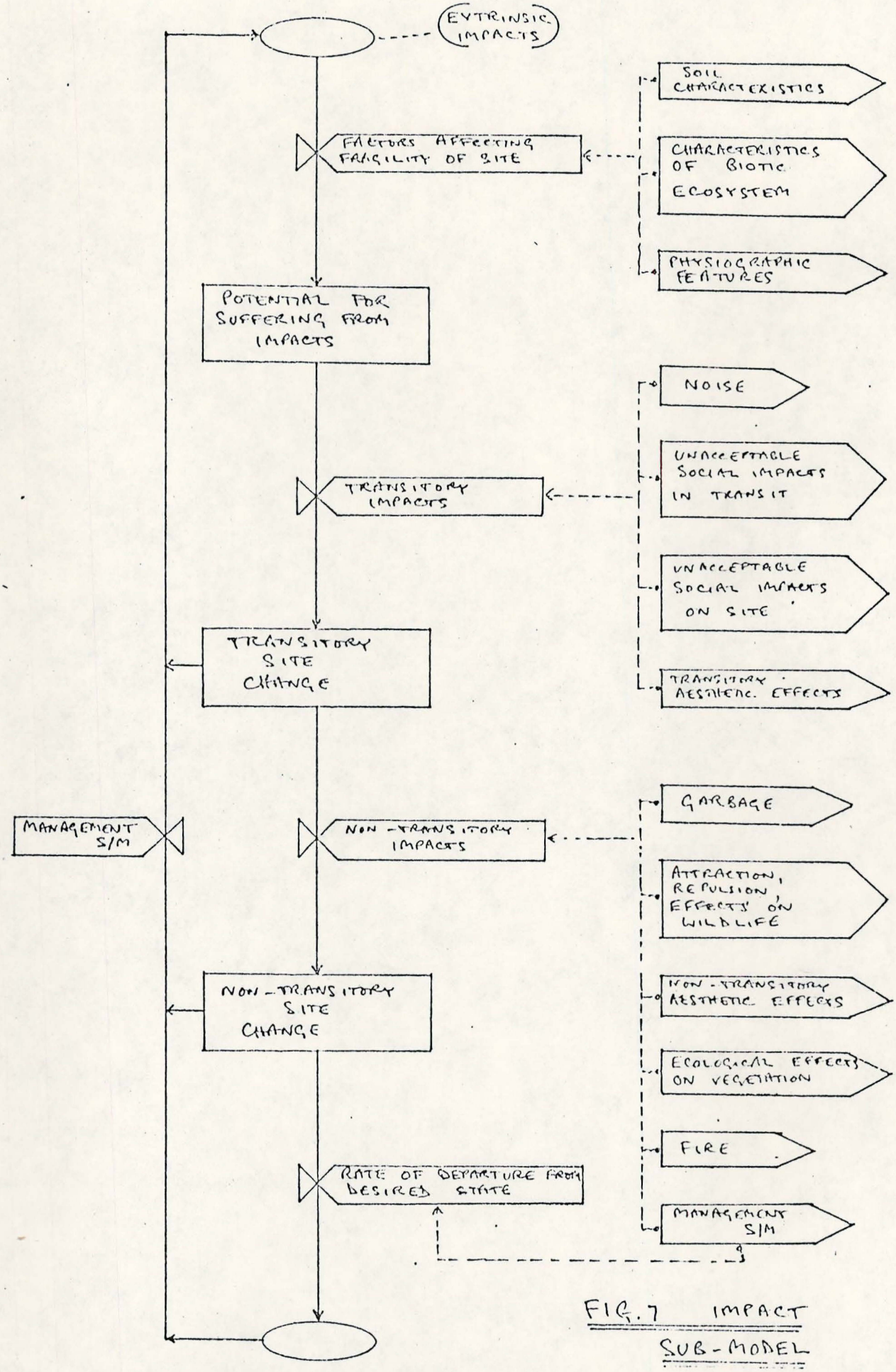


FIG. 7 IMPACT SUB-MODEL

this report deals in greater depth with ecological impacts. Finally, the sub-model in its present form cannot show (and distinguish between) magnitude and importance of impact (Clark and Stankey, 1979[a,b]). These concepts will be discussed later.

2.5 Discussion

The limitations of models such as these are obvious, and have been mentioned briefly in Section 2.1. Their value lies in simplifying complex systems, the better to perceive important state variables, and the influential rate variables and driving variables. With respect to the restricted class of recreational situations modelled in Figs. 1-7, it seems to me that the crucially important variables appear to be :

(i) state variables
- soil moisture
- soil organic matter
- net primary production
- access systems
- satisfying recreational experiences
- transitory site changes

and - non-transitory site changes

(ii) rate variables
- precipitation, infiltration, run-off and drainage
- growth, respiration and decomposition
- topography
- factors enhancing and diminishing recreational experiences
- visitor management
- fragility of site
- transitory impacts

and - non-transitory impacts

(iii) driving variables
- macro and micro fauna and flora
- means of conveyance
- access conditions
- costs
- time
- prior recreation experience
- recreational activities
- site acceptability
- site social acceptability
- acceptability of management regimes
- transitory impacts

and - non-transitory impacts

All of these variables have been studied by many workers in many different places: the Eagle Cap Wilderness could well be a place wherein most of them could be studied simultaneously and over a period long enough to -

(i) distinguish between transitory and non-transitory impacts;

(ii) gauge the acceptability to recreationists of impacts;

and (iii) see whether acceptabilities change through familiarity within one group or class of recreationists, or whether groups change towards those with lesser sensitivity to impacts.

Further recommendations will be made in Section 5.0.

3.0 SOILS IN RELATION TO SOME PROBLEMS IN WILDERNESS USE

3.1 Introduction

The problem with information about soils in relation to recreational use is not its paucity but its plethora. The topic has been a popular one, probably because many short-term effects of recreation on soils are spectacular, immediate and readily assessable by simple comparative measurements. However, some general problems with these studies are evident (Wall and Wright, 1977).

(i) They are often "after-the-fact", assume initial homogeneity of compared sites, assume that equilibrium has been reached, are rarely related to the intensity of use and often fail to assess the tolerance, rates of decline and changing species composition of plant communities.

(ii) They are usually short-term studies, on sites "chosen" by others (the recreationists) and often extend over too short a time for equilibrium to be established. Use intensities may change during the experiment.

(iii) Many studies have used simulated pressures, such as mechanical tramplers, and it is unclear as to how results from these studies can be extrapolated.

There is no shortage of reviews of the topic. Speight (1973), Liddle (1975), Satchell and Marren (1976) and Manning (1979) are but a few of the authors who have surveyed the literature in this field. Cole and Schreiner (in prep.) have compiled a comprehensive bibliography, which will be immensely useful for workers. The proceedings of a conference on recreational impact on wildlands, held in October 1978, have been edited by Ittner et al. (1979). Impacts of backcountry recreationists on wildlife have been reviewed by Ream (1980).

With all this information available it is difficult to know where to start, and how to make an original contribution. I was asked by David Cole to consider several topics, including effects of campsites, effects of burning downed wood, campsite and trailsite selection in relation to soils, rehabilitation of soils on recreational sites, soil compaction, and detection and monitoring of soil change. These topics are addressed in Section 3.3.

After reading the above reviews and many other reports of work in diverse recreational situations, I find it hard to escape the conclusion that, with four exceptions, the general effects of soils and on soils in relation to recreational use of wilderness are fairly well understood. At least, well enough understood to allow managers to take the results of appropriate studies and apply them to management. The problems, as I see them, are now in applying the results of soil-related research, rather than doing a great deal more. The four exceptions are :

(i) Well-designed quantitative field and laboratory studies of litter, fermentation and humus (LFH) layers and topsoil organic matter in relation to trampling and campfires.

(ii) Well-designed quantitative field and laboratory studies of the contribution of downed wood in particular wilderness plant communities to ecosystem dynamics. In my view, the report by Stanley et al. (1979) is an admirable example of such work.

(iii) Practical, long-term studies of methods of rehabilitation on over-used campsites and trails.

(iv) Development of standardised methods for detecting initial site changes, for monitoring further changes and for

communicating in a standardised format the state of particular wilderness ecosystems.

I shall return to these matters later in this Section.

3.2 General Aspects of Use-Impact Relationships

Section 2.0 attempted to model some of these relationships. Inevitably, the more detailed aspects were subsumed under broad headings as state or driving variables, and further detail is now needed. I see some possible ecological effects of campsite or trail use as follows, and classification into innocent and malicious, avoidable and non-avoidable impacts can be made for particular areas.

(i) Direct, probably non-avoidable, effects on soils.

- some soil compaction under tents and around camps
- some trail erosion
- some disturbance of soil by tent pegs and scuffing near tents
- some solid and liquid human and housekeeping waste
- some pollution of soil water
- some bare ground and loss of topsoil organic matter

These effects will be expressed as changes in -

- cover (plant death, slow recovery of site, inhibition of germination)
- exposure of tree roots
- influx of weeds
- loss of LFH layers
- loss of particular classes of soil separates
- sheet, rill and gully erosion

- changes in water stable aggregates and dispersibility
- changes in penetrability, bulk density and microporosity
- changes in soil shear strength
- nutrient changes
- changes in the infiltration-runoff balance

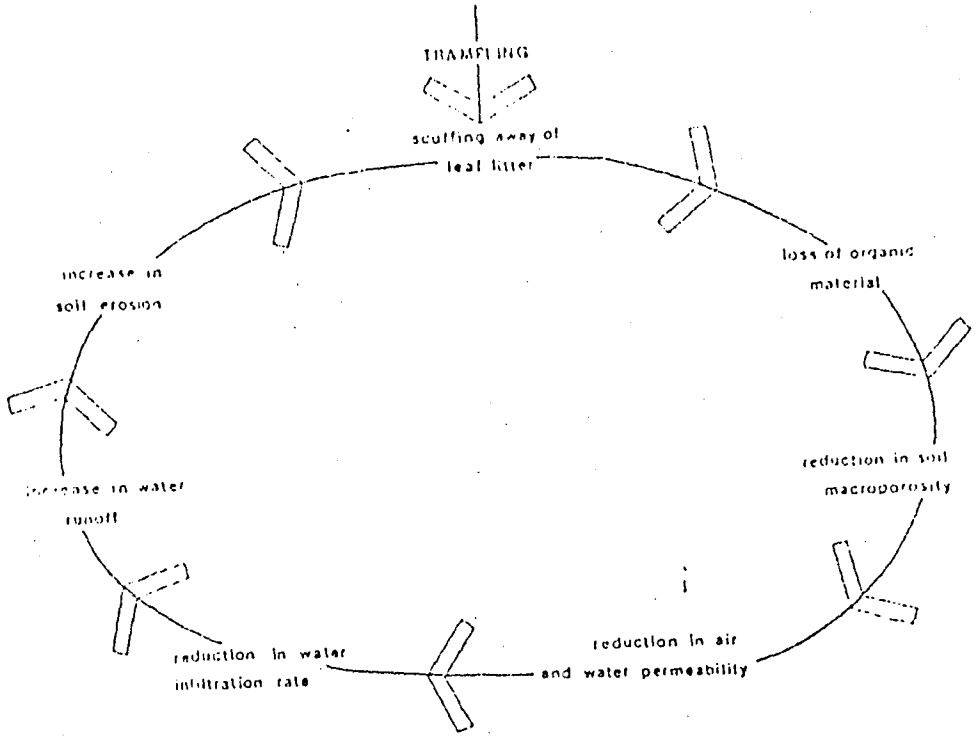
(ii) Indirect, probably avoidable, impacts on soils.

- removal of downed wood
- effects of foraging for downed wood
- damaging trees for firewood
- vandalism of trees, rocks and soils
- addition of ash from fires
- loss of organic matter after fires
- changes to microflora and fauna after fires
- changes of nutrient availability after fires
- development of hydrophobic soils under fires

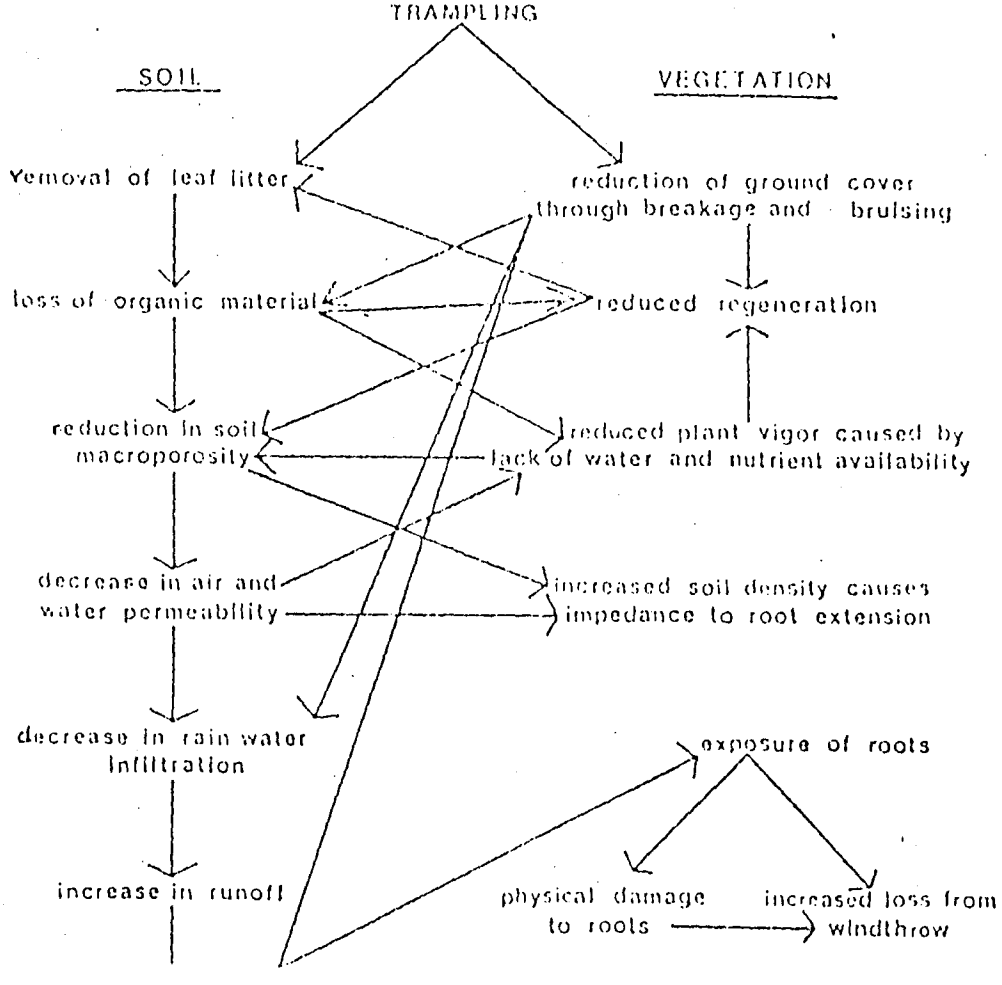
Manning (1979) has proposed a seven point soil impact cycle which summarised many of these effects, and combined this with effects on vegetation to give an impact model. It seems to me this is a most useful model, especially as it is dynamic and depicts stages of changes rather than merely the end results of impacts. These cycles are reproduced here as Fig. 8. Another useful approach is discussed by Jordan et al. (1972). Relative stabilities of mineral cycles within forest ecosystems are a function of the length of time taken to recover from some perturbation, with the ratio of recycling to steady-state input being an important determinant.

Various authors (Lucas, 1978; Manning, 1979; Cole, 1979; Cole and Stankey, 1980 unpub.) have demonstrated that impacts of recreation on soils are initially severe and rapid, even under light use, and thereafter occur at lesser rates. The shape of the curve could be sigmoidal (van Wagtendonk, 1977)

Fig. 3 From Manning, 1979


TRAMPLING
scuffing away of leaf litter
loss of organic material
reduction in soil macroporosity
reduction in air and water permeability
reduction in water infiltration rate
increase in water runoff
increase in soil erosion

Soil Impact Cycle.


TRAMPLING
SOIL
VEGETATION
removal of leaf litter
reduction of ground cover through breakage and bruising
loss of organic material
reduced regeneration
reduction in soil macroporosity
reduced plant vigor caused by lack of water and nutrient availability
decrease in air and water permeability
increased soil density causes impedance to root extension
decrease in rain water infiltration
exposure of roots
increase in runoff
physical damage to roots
increased loss from windthrow

but in my view (based on the above studies) is more likely to be asymptotic to a constant level (Fig. 9). An intercept is shown on the abscissa, because I believe some impact is evident everywhere even if the site is untrod, due to air and water pollution, dispersal of animals, noise and fire. It is possible that such a curve could have several stages, with different levels of impact achieved, perhaps after crossing some catastrophic threshhold (Fig. 10). Whatever the shape of the curve, the implications for distributing and rationing use, assuming for the moment a close correlation between use and impact, have been discussed by Cole (1980, unpub.) and Cole and Stankey (1980, unpub.). The only ways to change this impact-use relationship are :

(i) to impose virtually zero use levels;

(ii) to break the nexus between use and effects of use by developing low impact camping techniques;

and (iii) to harden sites and change the shape and/or axes of the graph.

Only (ii) is politically and socially feasible in wilderness. Severe impact seems almost inevitable even at very light use intensities, which means that some sort of "sacrifice area" concept probably has to be embraced if wilderness areas are not to be heavily impacted over high proportions of the utilisable area. The only way out of this impasse is to allocate research, money and management to discovering practical and rapid methods of site rehabilitation.

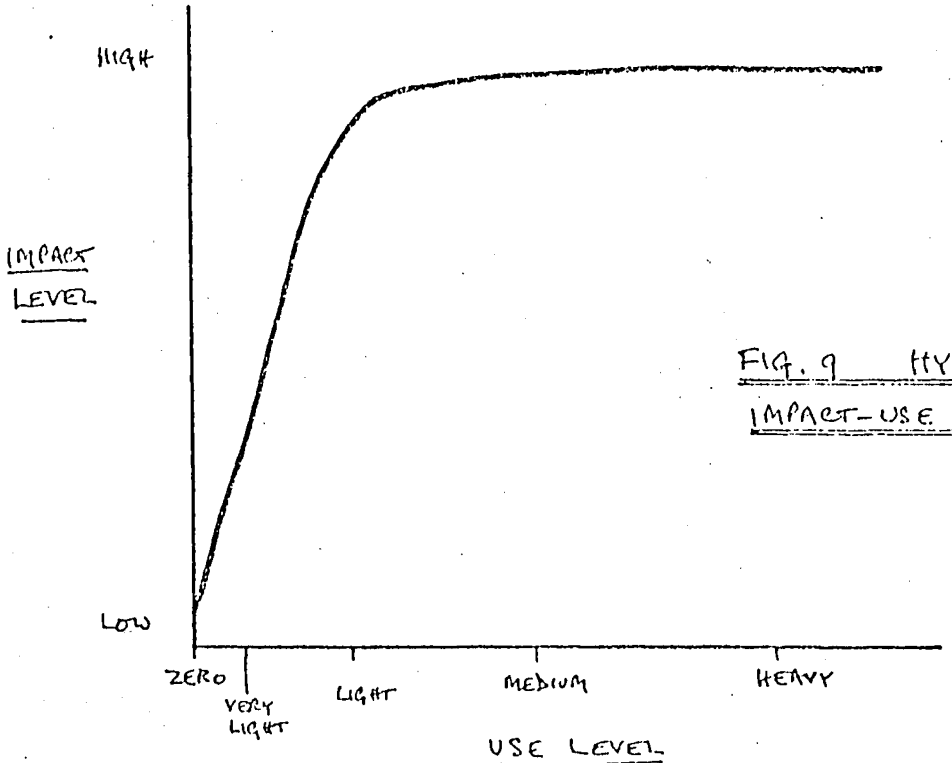


FIG. 9 HYPOTHETICAL IMPACT-USE RELATIONSHIP

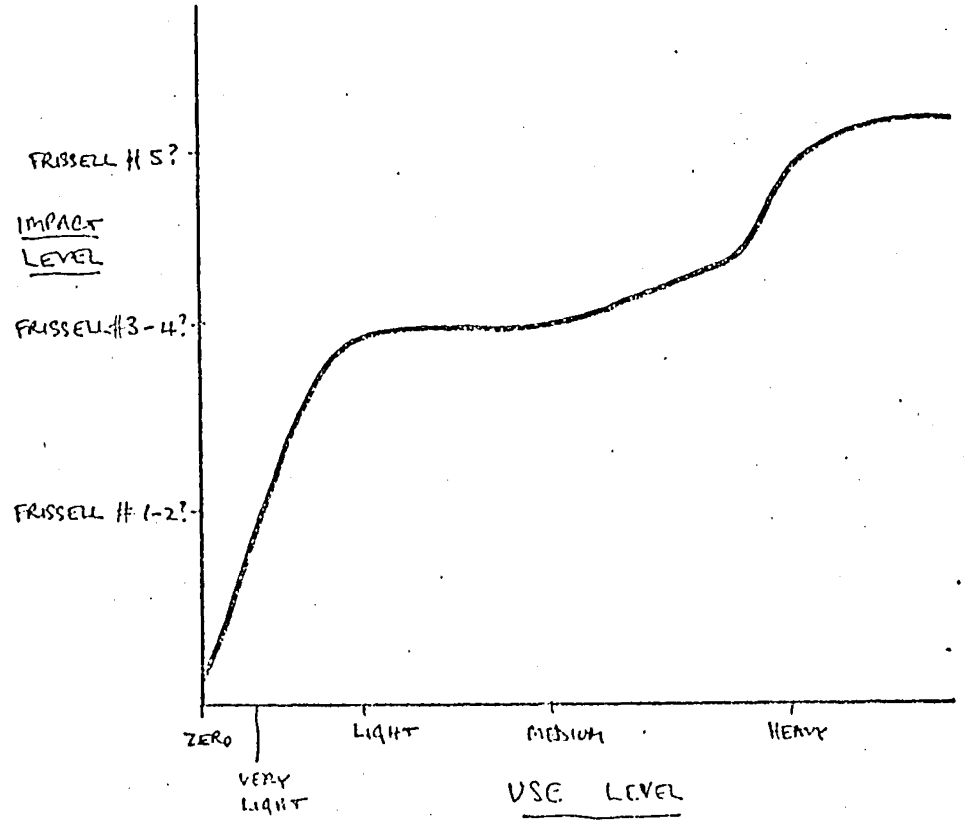


FIG. 10 HYPOTHETICAL IMPACT-USE RELATIONSHIP WITH SEVERAL STAGES OF IMPACT

3.3 Impacts, Site Durability, Management

3.3.1 Impacts

Lucas (1973) gives a tentative ranking from high to low of relative impacts by different types of recreating parties, ranging from large parties with horses through several other classes to minimum impact by small day hiking parties. The clear implication is that maximum impact is achieved by parties which are large, have pack and riding stock and who camp for lengthy periods, other things being equal. I believe this broadly accords with results reported by many other authors. The problem is, having proved many times that trampling affects soil bulk density, penetrability, bare ground, plant germination and a host of other soil characteristics in a host of different places, how does this help us now? Perhaps the only real advances can now be made for particular sites in -

(i) better selection of campsites and trail locations;

(ii) better knowledge of monitoring and rehabilitation;

and (iii) studies on the dynamic and long-term effects of campfires and wood removal on LFH layers, topsoil organic matter and ecosystem functioning.

The first two are discussed below. With regard to campfires, it is very easy to show, given appropriate sampling, that fires of different intensities will affect various soil characteristics, but the significance of these changes to forest ecosystems can only be discovered

by experiments done on-site and over lengthy periods. There may well be places where fires so change soil physical and biological characteristics that recolonisation is severely impeded. I was rather surprised by photographs shown to me of fire sites which had remained bare for longer than a decade following the last fire - such a phenomenon is quite outside my Australian experience. If such sites are common, then the only experimental approach is to study their chemistry and microbiology in field and laboratory in the hope that some factor will emerge which can be translated into effective recommendations for managers. Likewise, the significance for ecosystem functioning of burning downed wood can be studied by careful ecosystem dissection on a volume-weight basis to ascertain what proportions of organic matter and nutrients are destroyed or redistributed (Stanley et al. 1979). The approach described by Jordan et al. (1972) should be useful here. Figures in reports by Weaver and Forcella (1977) (and similar studies) would seem to indicate that nutrient contents of burnable downed wood represent a small proportion of total ecosystem nutrient capital, but these portions of the total ecosystem biomass may nevertheless be highly significant insofar as they provide relatively short-term additions of organic matter. They are also important sites for microbiological activity, and may shelter germinating seedlings and act as barriers to sheet erosion. This becomes extremely important in desert biomes used for recreation, such as Ayers Rock - Mt Olga National Park in Australia, where soil organic matter and sources for replenishment are minimal. High altitude biomes are similar in this respect.

The compaction problem seems to me to have been a little over-emphasised. It obviously occurs, it occurs rapidly and inevitably with even minimal traffic and it clearly has important effects on ecosystems (Liddle, 1975;

Manning, 1979). I am unsure of the extent to which subsoils are affected by surface compaction. But it must then reach some sort of dynamic equilibrium. Given rest, or rehabilitation, the topsoils will gain organic matter and eventually should return to bulk densities resembling the initial state. Parsons and de Benedetti (1977) described this process, although I have some reservations about the comparability of their study areas.

3.3.2 Site selection and durability

Helgath (1975) found that trail deterioration was poorly correlated with trail use, but better related to landform, vegetation and trail grade. I feel that the more general case is outlined by Leonard and Plumley (1977), who gave an excellent set of "rules" for planning site use based on the ability of the soil to drain, resist erosion, support plant growth and promote decomposition of waste (their Tables 1-4). These factors have been further discussed by Cole (pers. comm.) in an extraordinarily comprehensive, practical and detailed list of factors for consideration when selecting sites and designing trails and campsites. In no way can I improve upon the reports of these two authors.

3.3.3 Management for monitoring, detection and rehabilitation

In managing recreation impacts, the wilderness manager needs workable systems for

(i) describing impact states
(ii) detecting early stages
(iii) monitoring the changes
and (iv) rehabilitating the ecosystems

given particular general ambit rules for given ecosystems. The first of these will be discussed in Section 3.4.

Early changes can only be detected by the manager if he knows which are the significant ecological changes, and has methods to measure them. Cole (1980 unpub.) showed (p. 38) that "variables which do show meaningful differences related to amount of use are bare ground, bare area, duff depth and trees with exposed roots". All are relatively easy to measure with methods standardised for given areas. Although I did not have time or opportunity to test them, determination of soil shear strength and topsoil water stable aggregates have given useful results in predicting soil erodibility. Both characteristics are closely related to one important variable in the Universal Soil Loss Equation, where soil loss is a product of rainfall intensity, length of slope, steepness of slope, cover management, conservation practices and soil erodibility. Cover will clearly be important in preventing erosion, but erosion will not occur until detachment and transportation take place. These are conditioned by erodibility. There are many other measures of soil erodibility, such as Middleton's dispersion ratio, but the proportion of water stable aggregates is a sensitive and flexible integrating indicator of the ability of the soil to resist erosion. Considering that soil erosion, especially gully erosion, is probably the most serious non-transitory impact, the routine measurement of WSA could be a useful parameter to monitor.

Lastly, rehabilitation of sites is obviously best done by resting the site (Parsons and de Benedetti, 1977), and this is certainly the cheapest method. Unfortunately, it may not be practical in many circumstances. Scarification can be of value if it can be shown that recolonisation is being impeded by compacted soils, and

it may be essential if direct seeding or planting seedlings is contemplated. In Australia, eucalypt forests generally require scarification and fires to regenerate cut-over forests, although this often stimulates "weed" species. I would have grave doubts about using fertilisers, even slow release forms, in wilderness ecosystems, mainly because they may drastically change the course of ecological succession and may pollute water bodies. In this respect they are probably against the spirit of the Wilderness Act. Hand watering of seedlings would no doubt be permissible, and might help considerably in establishment.

Provided a wilderness soil is permitted or helped to regain most of its initial characteristics, particularly organic matter content, it should then recolonise in time, or should support planted seedlings of local species. Massively eroded sites will need to have their profiles reconstructed, if this is possible without damaging adjacent sites. Again, Cole (pers. comm.) has listed numerous techniques for maintenance and rehabilitation. Finally, Cole and Dalle-Molle (pers. comm.) have summarised much information about backcountry campfire impacts into a practical guide notable for its commonsense.

3.4 A New Site Impact Rating System?

Frissell (1978) described a method of judging recreation impacts in wilderness campsites using visual criteria. The rating system has five classes, based on progressive changes in ground vegetation, surface litter layers, bare ground, exposure of tree roots and apparent erosion. Cole (1980, unpub.) tested the system in the Eagle Cap Wilderness and found it was generally "the best overall indicator of campsite condition". It attempts to (a) correlate visual state with ecological state, and (b) communicate ecosystem condition unambiguously and in a standard-

ised format. Cole found two main problems in using this method. Firstly, the classes (especially Class 4) were too wide and did not adequately distinguish between degree of impact on severely impacted sites. Secondly, the rating system does not describe the condition of individual site parameters, but amalgamates them in a few broad classes where the weighting of parameters is uncertain.

The Frissell system could be improved by increasing the number of classes and/or by subdividing several of the classes. It might be possible to assign magnitude and importance symbols within each class, after the manner of the Leopold matrix system for environmental impact assessment. Thus, within each class one could take an apparently important characteristic, such as bare ground or bare soil, and assign 1-10 for magnitude (on some standard scale) and 1-10 for importance (on some arbitrary but standard scale). However, most users of this system in the Leopold matrix have found it difficult to assign standards, to assure comparability and to manipulate the 1-10 ratings. Another approach might be to develop the Manning (1979) soil impact cycle (Fig. 8 in this report) as a workable impact rating system.

In my view, any rating system should make an overt attempt to relate impact rating to those characteristics of the ecosystem which have most influence on unimpaired continuation of ecological processes within that ecosystem. It would be necessary to identify those characteristics of a particular type of ecosystem which relate to maintaining ecological vigour and unimpeded ecological cycles and successions, and which promote dynamic equilibria in systems at an apparent steady-state. Such characteristics could include cover, topsoil depth, regeneration, depth of LFH layers, pH, soil nutrients (determined on a volume-weight basis), soil moisture capacity, and perhaps various phenological and reproductive characteristics of the plant community. Several of these would not be easy to determine, at least not on a routine basis. It is not easy to

decide which characteristics are "most important" to the healthy functioning of an ecosystem, especially given the truism that the characteristics of an ecosystem are intimately inter-related. Perhaps attention should be focussed on those ecosystem attributes which change most rapidly, since these are likely to be most and earliest affected by recreational use. This group would include topsoil depth, depth of LFH layers, water stable aggregates and bulk density (expressed as log penetrability) as soil attributes, and bare ground, seedling regeneration and vegetation damage as plant attributes. A scale might then be arranged so that 1, 2 and 3 represent changes from "good" to "poorer" conditions, with the connotation that all three represent relatively satisfactory conditions wherein a return to 1 from 3 is easily accomplished by rest and/or some minor rehabilitation. Ratings 4, 5 and 6 might then indicate a progressive deterioration from "poor" to "catastrophic" conditions, with return from 6 to 4, and thence to 1, requiring lengthy spelling and major rehabilitation. Clearly, such a system would have to be developed anew for each type of ecosystem within given ecological strata, but I would see it having two real advantages. Firstly, it might focus attention on attributes which are not merely visual expressions of change, but are truly significant in maintaining ecological stability. Secondly, such a site impact rating system (SIRS) could be capable of providing region-wide or even nation-wide standardised and comparable measures of degree of recreational impact.

4.0 ACCEPTABLE IMPACTS

4.1 Introduction

In 1916 Congress established the National Park Service and instructed it "... to conserve the scenery and natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations". The key words in this passage are conserve, provide...enjoyment, by such means, leave unimpaired and enjoyment of future. The resolution of this inbuilt paradox has increasingly bedevilled park managers and park users, especially as use increases rapidly and diverse impacts become inevitable and obvious. Management of National Parks, and wilderness areas managed in sympathy with these ideals and the 1964 Wilderness Act, has led to attempts to determine carrying capacities: generally defined with reference to use levels under certain management regimes which avoid "excessive damage" to physical-biological environments and attempt to maintain satisfaction for the visitor. Such phrases as "acceptable impact", "significant impact" and "substantially unaltered" appear frequently in the literature, but with little precise explanation. Clearly, the problem of "acceptable to whom?", and the difficulties of setting unequivocal yet responsible and sensible standards of maximum allowable ecological change, are major and complex questions. Unfortunately, maximum allowable change can tend to become the normal amount of change, and thence provide a new benchmark for further determinations of greater maximum allowable change.

4.2 Some Further Considerations

All recreationists have their own ideas about acceptability of impact, and these will be as diverse as people are diverse. The ideas may be held flexibly or inflexibly, but over a lengthy period of time will drift in the direction of greater or lesser

purism with respect to the stratum of the recreation opportunity spectrum being considered. Historically, I suppose the degree of purism is more likely to decline than increase, although this might change as some parts of the spectrum are perceived as becoming endangered. The tolerance levels of given groups can change, and/or the groups utilising some recreation space will change so other groups with greater tolerance will occupy the recreation niche. I guess the process is almost analogous to the replacement in an ecological niche of an intolerant, non-plastic species with an aggressive, tolerant, plastic species! Examples abound in the ecological literature. The processes of visitor-type change and visitor accommodation to greater impact are nicely described in the Preface to Clark and Stankey (1979a). It is probably true to say that wilderness managers are less tolerant of impact and less flexible in their convictions than most recreationists, but the situation is little understood (Lucas, 1979).

In relation to acceptable or unacceptable impact due to allegedly distasteful objects and experience, the visitor -

> either sees/experiences and likes (or doesn't dislike),
> or sees/experiences and dislikes,
> or doesn't see/experience.

I believe one key to minimising some unacceptable impacts lies in the third of these alternatives. "What the eye doesn't see, the heart doesn't grieve" may well be a useful management tool, to which I will refer later in the next Section.

The phrase "acceptable impact" tends to imply impact on site, rather than impact on people, which is more properly related to the degree of achievement of a satisfying recreation experience. It has biocentric rather than anthropocentric bias. However, it must be admitted that the two concepts are somewhat inter-related, though to what extent seems to be unclear.

"Acceptable impact" should also, if possible, be distinguished from acceptable outdoor recreation behaviour, which is related to the value system of recreationists.

Frissell et al. (1980) and Lindsay (1980), among others, have emphasised that the question of "How much change is acceptable?" can only be judged against sets of standards promulgated through management objectives and management actions. The setting of such standards, and decisions about the attributes for which minimum standards should be set, become elusively slippery matters unless there are some guidelines anchored in measureable and ecologically significant phenomena. It is the difference between the value-laden concept of importance versus the supposedly objective assessment of magnitude (Clark and Stankey, 1979a+b). Lucas (1979) has also described the importance of understanding factors affecting the viewer's perception of an impact.

Frissell and Stankey (1972) and Hendee et al. (1978) have discussed many of the important and often confusing concepts involved in setting limits of acceptable change, and they qualitatively depicted acceptable variations in ecological and wilderness experiences, with emphasis on variations in character of change and rate of change. Most standards of acceptability will be rather site-specific and perhaps somewhat transient, except where based on ecological processes (and legal requirements) which are qualitatively and quantitatively common to particular biomes or biological sub-regions.

4.3 A Decision-Making Framework

It is time to attempt to construct a decision-making framework. Figure 11 represents such an attempt. I see the process of choosing standards of acceptable impacts as having several decision-making levels. Having stratified an area, in this case wilderness, within the recreation opportunity spectrum,

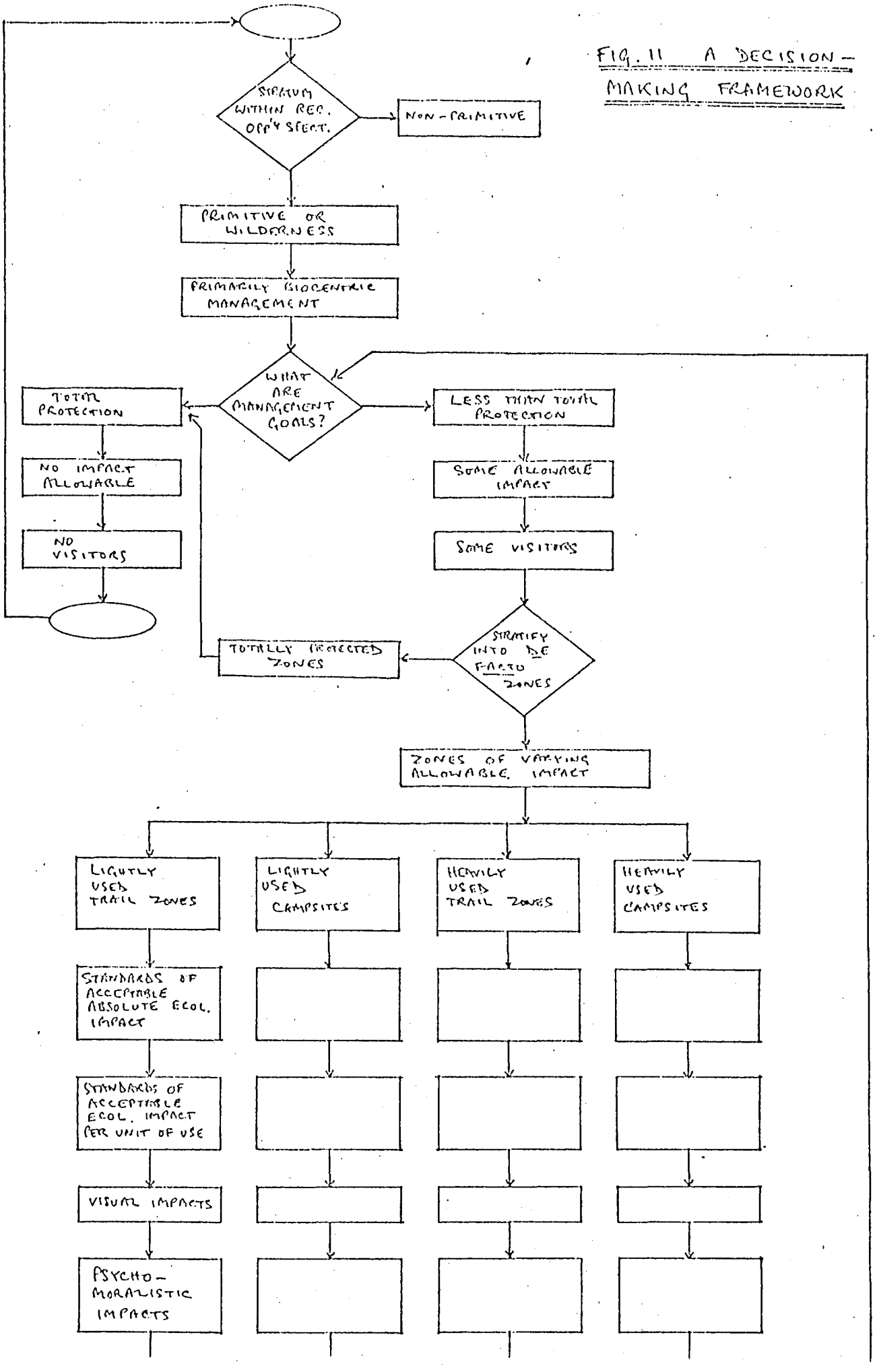


FIG. 11 A DECISION-MAKING FRAMEWORK

management becomes primarily guided and governed by biocentric concerns. These set management goals, one of which could be to give total protection, meaning no allowable impact and no visitors. Even in the few places where this approaches feasibility (for example, some remote islands reserved for infrequent observational research) it is worth noting that management of fire, wildlife and other ecological attributes is still necessary. In the more usual case, there is less than total protection, leading to some allowable impact due to some visitors. It is here that I stratify the wilderness into de facto zones of varying allowable impact. One zone might be totally protected, others are lightly and heavily used "trail zones" and campsites. A "trail zone", in my view, is the trail itself and the foreground, as defined by USDA Forest Service (1974, p.7). A trail is any land used as a transport corridor, and need not have a formed surface. Each of these zones will then have different set standards of acceptable absolute ecological impact, and acceptable impact per unit of use. Both sets of standards will be most stringent for lightly used trail zones, and least stringent for heavily used campsites. Management inputs, as to amount and timing, are adjusted accordingly. Having set these standards (see below), different psycho-moralistic and visual impacts are allowable in different zones (see below). Management feedbacks are shown to the source, and also to re-set or confirm management goals as seems appropriate within an evolving socio-political environment. Lastly, Lucas (1979) has suggested that management standards should be based mainly on professional recognition of longer-term consequences of impacts, and on legal and policy goals. Both appear high in the decision-tree in Fig. 11.

Next comes the thorny problem of setting operationally feasible standards. Hendee et al. (1978, p. 181-183) discussed situations where a change in the character of an ecosystem takes place. I would suggest that little change of this sort is allowable in wilderness ecosystems, even in the heavily used

zones. How little can probably only be assessed in relation to some knowledge of normal character changes expectable in particular ecosystems, and this is highly site-specific. Any change in character which perturbs an ecosystem so markedly that it cannot return to its initial state (or the state it would have been in had it continued evolving) in any sensible ecological time-scale is probably unacceptable. Hendee et al. (1978) also discussed unacceptable changes in the rates of normal change in ecosystems, and gave two examples of exponential and linear rates of change. The former generally allows some definition of the limit of acceptable change (at the point of inflexion of the curve), but the latter does not help to establish the limits. Examples of the former are sudden topsoil aggregate instability, and sudden erosion after a resistant soil horizon has been finally worn down. States et al. (1978, p. 1-4) quoted a definition which could be made operational:

"...an impact is significant if it results in a change that is measureable in a statistically sound sampling program and if it persists, or is expected to persist, more than several years at the population, community or ecosystem level".

This seems to be a sounder approach than setting an arbitrary degree of change (such as a loss of 50% of ground cover), unless that figure can be related directly to a measureable and relatively permanent deflection of normal ecosystem dynamics, leading to a non-continuation of the desired ecological system. A standard based on the most sensitive ecological attribute could be chosen to give an early indicator of unacceptable change. One might choose loss of some proportion of LFH layers (either L, or L+F, or L+F+H). This approach might pose two problems. Firstly, the most sensitive plant or soil indicator (if it can be discerned) need not be the most ecologically important and, secondly, setting standards based on highly sensitive indicators would probably be unrealistically and impractically stringent in all except lightly used trail zones.

I am less sure of criteria for visual impacts. I am convinced (see Section 4.2) that managers could "fool most of the people most of the time" if they were to spend relatively small amounts of time and money cleaning up those aspects of a site which are generally likely to be regarded as visually distasteful or inappropriate. Lucas (1979) reported that there seems to be rather limited perception of impacts, and rather weak correlation with reduction of satisfaction, but I cannot help feeling that people adjust to visual blights which, when removed, screened or corrected provide great and unexpected satisfaction. What criteria could be used to decide visual inappropriateness? The Visual Management System (USDA Forest Service, 1974) might help us here, although my ideas are poorly formed due to unfamiliarity with concepts of landscape architecture. The VMS gives 14 critical premises upon which any consideration of visual character can be based. They are :

- expected images exist
- aesthetic concern varies and types of viewers are critical
- view duration is critical
- number of viewers is critical
- all lands are viewed
- diverse landscape character is important
- retention of character is desirable
- the capacity of each landscape to absorb alteration without losing its visual character is critical
- the visual impact and character of management activities is critical
- focus of viewer attention is critical
- alteration of character may be desired
- viewing distance is critical
- viewing angle is critical

and - management is necessary

I would suggest that management attention to the visual character of a campsite, for instance, could be focussed strongly upon inappropriate

- objects (e.g. garbage, manure)
- form (e.g. shapes of man-made objects, eroded land)
- line (e.g. stumps and logs cut in straight lines)
- colour (e.g. changes of colour due to loss of vegetation)
- texture (e.g. eroded land, bare ground)

Standards of inappropriateness should not be too difficult to determine, based on commonsense, surveys of general visitor beliefs, and jarring form, line, colour and texture. Most of us are easily able to detect any form, line, colour or texture which is not consonant with the surrounds, whereas the same object when camouflaged is acceptable. If this were done I would hazard a guess that many impacts, even though still ecologically unacceptable, would give greater visitor satisfaction and might allow breathing space for rehabilitation.

The term "psycho-moralistic impacts", though rather infelicitous and unacceptably ugly, seems to me to combine and embrace those impacts related to psychological satisfaction (such as encounters, perceived crowding and distaste for observed visitor behaviour) with those of a moral nature (such as the fervent purist attitudes exhibited by some wilderness devotees). It relates also to the opportunity setting factor of "acceptable regimentation" (Clark and Stankey, 1979a). It involves the values people hold about wilderness (Clark and Stankey, 1979b). Purist attitudes were explored by Stankey (1972). No doubt, unacceptable impacts as perceived on a psycho-moralistic plane are responsible for dispossessing many purists from particular wildernesses, though how much wilderness management should or could attempt to satisfy the

the purist is a question I am not able to explore. Could the wilderness purist be regarded as an endangered species, like the grizzly bear, and thus qualify for special treatment by management? Stringent management consonant with rigid purist attitudes is appropriate for lightly-used zones (Fig. 11).

Lastly, management has overwhelming importance in Fig. 11, and obviously the professional attitudes, judgements and skills of the manager must be trusted to play a large role in setting standards for acceptability. Some of these will inevitably seem arbitrary, being based on the manager's conception of "the fitness of things". The manager will govern the degree of acceptable regimentation, which will have social impacts. There is a danger that the effects of management, especially in site grooming, could have more serious impacts than the impacts they are attempting to control (Clark and Stankey, 1979b).

5.0 RESEARCH RECOMMENDATIONS

The following lists collate and summarise many of the points made in Sections 2.0, 3.0 and 4.0. I have grouped them into five categories, and the order within each category reflects my assessment of the relative importance of the research topics, although this does not mean that the last topics in each group are unimportant. Clearly, the categories chosen are somewhat arbitrary and over-lapping.

Studies directly related to soils

Determination of the soil characteristics most sensitive to change.

Long-term studies of soil changes due to different intensities and directions of use.

Quantitative field and laboratory studies of litter, fermentation and humus (LFH) layers and topsoil organic matter in relation to trampling and campfires.

Topsoil moisture regimes in relation to degree of impact.

Assessment of the infiltration-runoff balance for comparable impacted and non-impacted soils.

Detailed micro-studies of soil erosion on campsites.

Aggregate stability, water-stable aggregates, soil dispersibility and changes in soil separates in relation to use levels.

Detailed studies of penetrability, bulk-density and microporosity horizontally and vertically on and in soil profiles.

Soil microfauna and microflora as early indicators of impact.

Soil shear strength as an early indicator of impact.

Topsoil water-stable aggregates as an early indicator of impact.

Quantitative studies of rates and amounts of soil disturbance around hitching rails (and trees used for hitching) in relation to amount and timing of stock use.

Amount and nature of manure added by pack and riding stock, and effects on soils.

Effects of household waste on wilderness soils and soil water. Rates of decomposition in different soils.

Development of soil hydrophobia after campfires: vertical and horizontal extent, nature and longevity.

Ecological studies

Better knowledge of the magnitude and importance of site responses to recreational use.

Better understanding of the degree of linkage between use per se and effects of use.

Development of standardised methods for detecting initial site changes, for monitoring further changes and for communicating in a standardised format the state of particular wilderness ecosystems.

Expected (normal) character change in ecosystem cycles, successions and apparent steady-states.

Expected (normal) rates of change in ecosystem cycles and successions, and expected rates of attainment of apparent steady-states.

More comprehensive and realistic models of the integrated inputs, outputs and feedback loops related to recreational sites, however defined.

Detailed studies of the dynamics of trampling on a particular site, with emphasis on effects on seedbed formation, seed germination and establishment of recolonising species.

Stabilities of mineral cycles in forested ecosystems in relation to perturbations and steady-state inputs.

Classification of biomasses of different sizes of downed wood to clarify which sizes could be burned without unacceptable impact on ecological cycles.

Quantitative studies of the importance of downed wood as sites for sheltering germinating seedlings and as barriers to sheet erosion.

Quantitative field and laboratory studies of the contribution of downed wood in particular wilderness plant communities to ecosystem dynamics.

Weeds on impacted sites.

Visual impacts

Development of visual management system criteria to aid minimisation of visual impact.

Exploration of form, line, colour and texture in wilderness campsites and trail zones.

Exploration of perceived visual inappropriateness of objects and impacts in wilderness campsites and trail zones.

Social science

Use of the Recreation Opportunity Spectrum to specify and stratify sites according to their role in shaping levels of acceptable impact.

Social surveys of the perceived importance of particular impacts in/on particular sites.

Classification and clarification of impacts for particular sites to distinguish those which are transitory, avoidable and trivial from those which are non-transitory, non-avoidable (given present management) and serious.

Manager's attitudes to soil impacts and soil changes.

Visitor attitudes to soil changes.

"Drift" of psycho-moralistic attitudes in relation to increasing familiarity with impact.

Innocent/malicious behaviour.

Management

Practical, long-term studies of methods of rehabilitation on over-used campsites and trails.

Studies of scarification, irrigation and fertilisation in rehabilitating impacted wilderness sites.

Development of a new Site Impact Rating System, with emphasis on those characteristics which have most influence on unimpaired continuation of ecological processes within particular ecosystems.

Surveys of nature and amount of garbage in wilderness campsites and trail zones.

Exploration of the possibly deleterious effects of site grooming.

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